

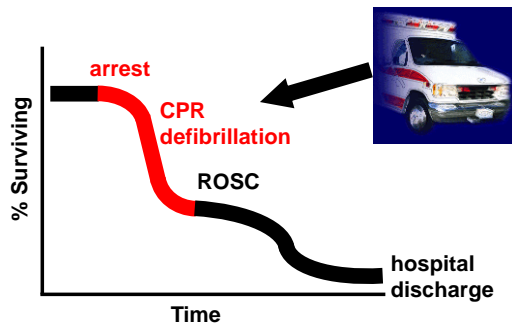
## Bringing Science to the Pit Crew: High-Functioning EMS CPR Teams

Douglas F. Kupas, MD, EMT-P  
Commonwealth EMS Medical Director

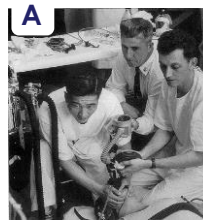
## Bringing Science to the Pit Crew: High-Functioning EMS CPR Teams

"The Science"

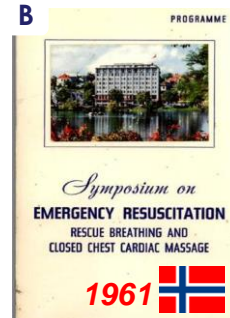
Cardiac arrest is the ultimate EMS disease!



CPR is over 50 years old, but recent changes have shown increases in survival

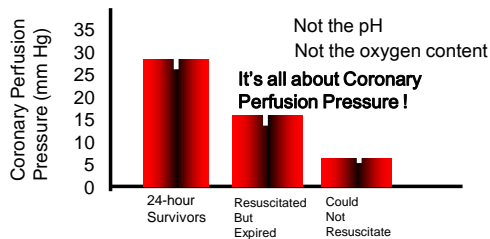


A. Peter Safar, 1950s



B. Early symposium on CPR

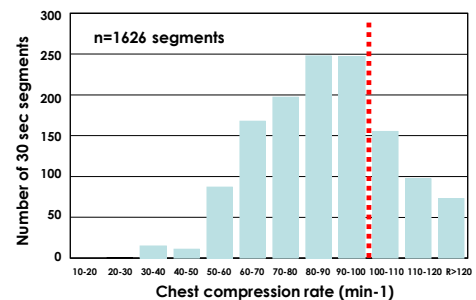
Survival is related to arterial pressures generated by chest compressions



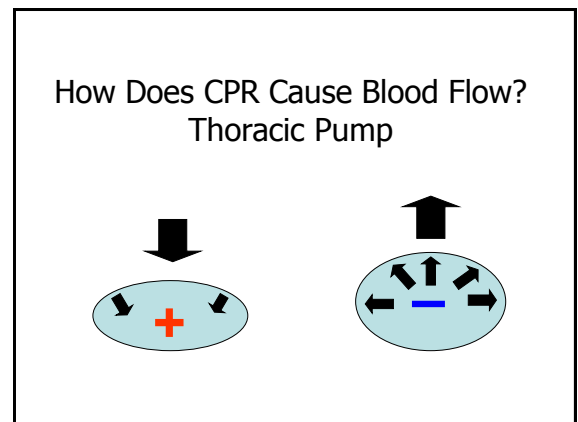
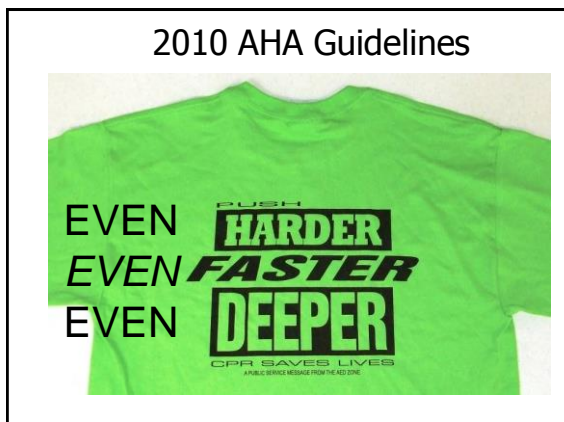
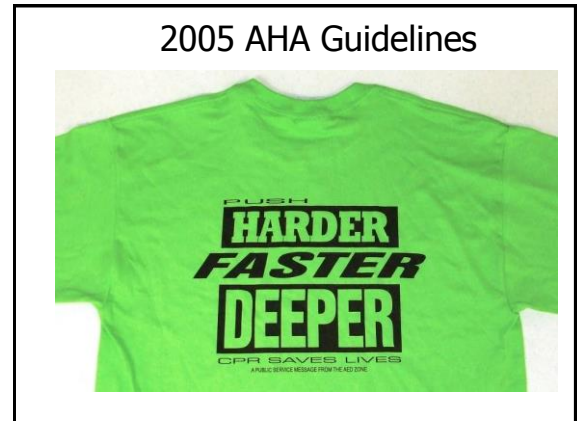
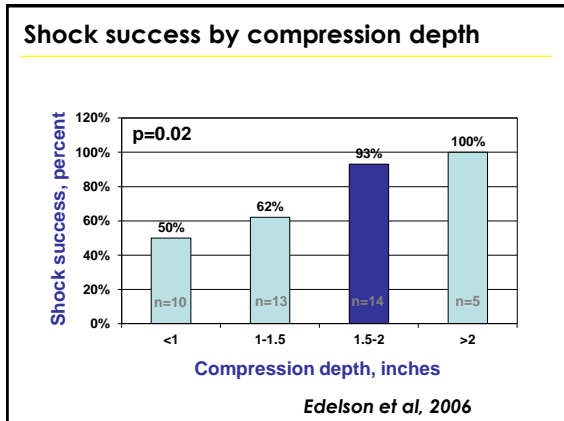
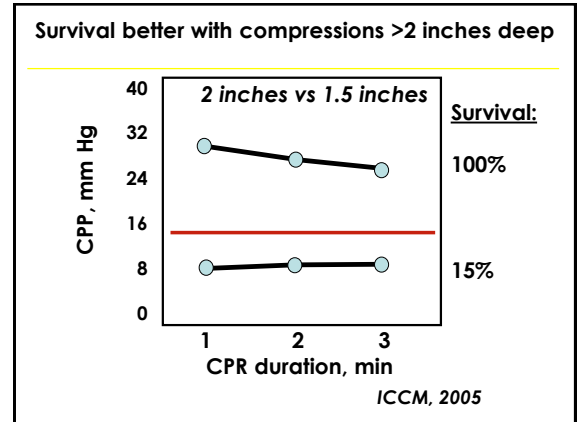
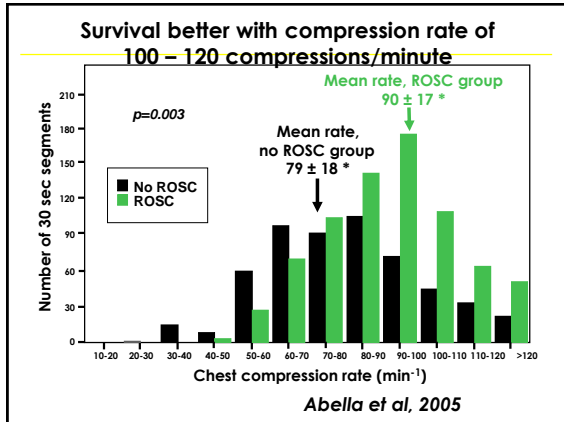
Kern, Ewy, Voorhees, Babbs, Tacker *Resuscitation* 1988; 16: 241-250

Paradis *et al. JAMA* 1990; 263:1106

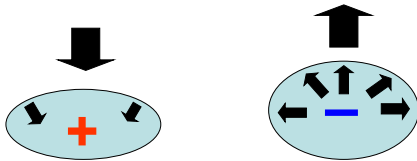
## Chest compression rates



Abella *et al.*, 2005



- Ensure Total Chest Recoil with:
- 1) Lifting palm during compressions
  - or
  - 2) Using feedback device



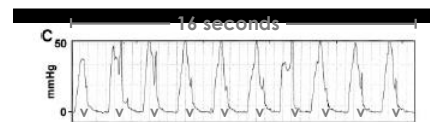
Allow Complete Recoil  
Lift Palms During Compressions

### CPR sensing and recording defibrillator



Examples: Devices providing real-time feedback are available from several manufacturers

### Patients can be hyperventilated to DEATH!

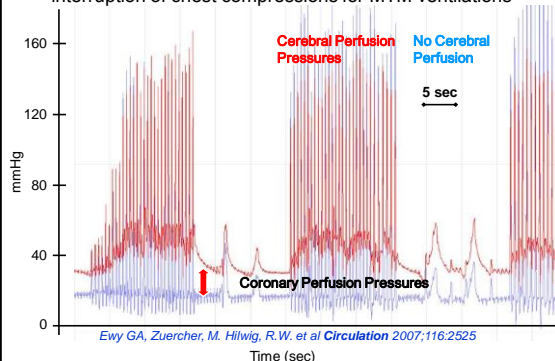


mean ventilation rate:  $30 \pm 3.2$

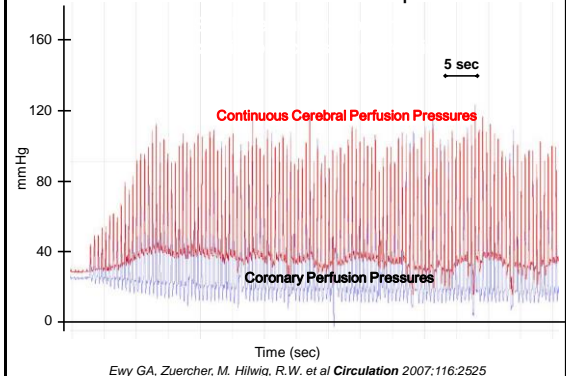
first group:  $37 \pm 4$  → after retraining:  $22 \pm 3$

*Aufderheide et al, 2004*

Single rescuer performing 30:2 with realistic 16 sec. interruption of chest compressions for MTM ventilations



Perfusion with continuous compressions



## CPR before defibrillation may increase survival (when CA not witnessed by EMS)

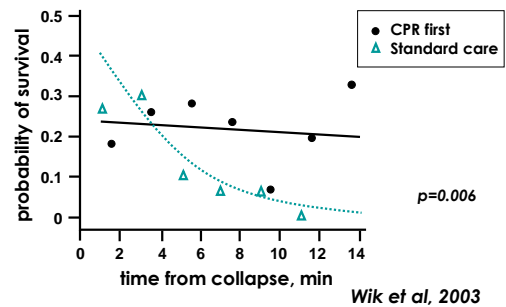
Influence of cardiopulmonary resuscitation prior to defibrillation in patients with out-of-hospital ventricular fibrillation

24% (155/639) 30% (142/478)  $p=0.04$

Defib first 42 months	CPR (90 sec) first, then defib 36 months
--------------------------	---

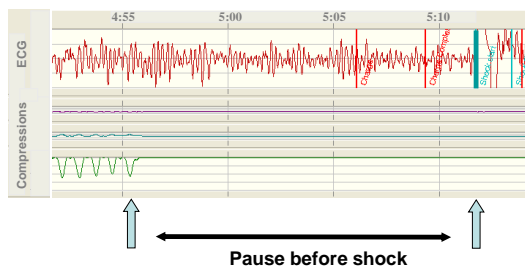
Cobb et al, 1999

## CPR first may improve survival: RCT

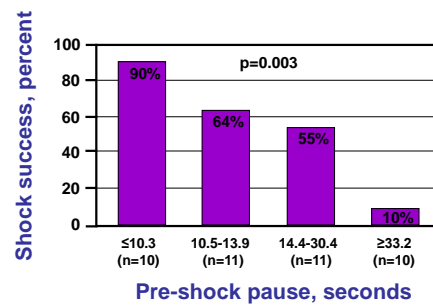


Wik et al, 2003

## Chest compression pauses before shocks



## Shock success by pre-shock pauses



Edelson et al, 2006

## CPR renaissance: measuring CPR matters

### Interruptions of Chest Compressions During Emergency

Terence D. V.  
Marc D. Berg

### Quality of Cardiopulmonary Resuscitation During Out-of-Hospital Cardiac Arrest

Lars Wik, MD, PhD  
Jo Kramer-Johnsen, MD

Context: Cardiopulmonary resuscitation (CPR) guidelines recommend target values for compressions, ventilations, and CPR-free intervals allowed for rhythm analysis and

### Quality of Cardiopulmonary Resuscitation

### Hyperventilation-Induced Hypotension During Cardiopulmonary Resuscitation

Tom P. Aufderheide, MD; Gardar Sigurdsson, MD; Ronald G. Pirralo, MD, MHSA;  
Dimitris Yannopoulos, MD; Scott McKnite, BA; Chris von Briesen, BA, EMT;  
Christopher W. Sparks, EMT; Craig J. Couard, RN; Terry A. Provo, BA, EMT-P; Keith G. Lurie, MD

Valenzuela et al, *Circ* 2005

Wik et al, *JAMA* 2005

Abella et al, *JAMA* 2005

Aufderheide et al, *Circ* 2004

## Gasping Should Not Distract from Recognizing Patient in Cardiac Arrest

- EMD recordings of 445 witnessed cardiac arrests
- Non-witnessed arrest: 16% gasping
- Witnessed arrest: 55% gasping ( $p < 0.001$ )

Clark et al. *Ann Emerg Med* 1992;21:1464

## Medications proven to improve outcome in cardiac arrest?

- 
- 
- 

## The priority is quality compressions

### Intravenous Drug Administration During Out-of-Hospital Cardiac Arrest A Randomized Trial

Theresa M. O'Keefe, MD  
Kurt Sunde, MD, PhD  
Catherine Bradbury, MS  
Jon Thomsen  
Peter A. Stone, MD, PhD  
Lars Wik, MD, PhD

**Context:** Intravenous access and drug administration are included in advanced cardiac life support (ACLS) guidelines despite a lack of evidence for improved outcome. Epinephrine was an independent predictor of poor outcome in a large epidemiological study, possibly due to toxicity of the drug or cardiopulmonary resuscitation (CPR) interruptions secondary to establishing an intravenous line and drug administration.

**Objective:** To determine whether removing intravenous drug administration from an ACLS protocol would improve survival to hospital discharge after out-of-hospital cardiac arrest.

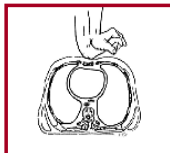
2009



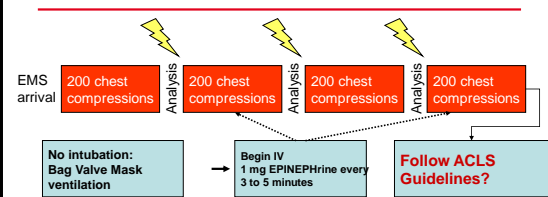
**Randomized trial of EPINEPHrine versus no EPINEPHrine For EMS treated cardiac arrest → NO BENEFIT IN SURVIVAL TO DISCHARGE FROM HOSPITAL!**

## Key "take home" points

1. Cardiac arrest is not hopeless!
2. CPR quality has biggest impact
  - Adequate chest compression rate (100-120/min)
  - Maximize chest compression depth (>2 in.)
  - Allow for complete chest recoil
  - Minimize pauses !!
3. Minimize ventilations (8-10 bpm)
4. Use capnography & debriefing, consider CPR feedback tools
5. Ensure access to hypothermia and cardiac catheterization

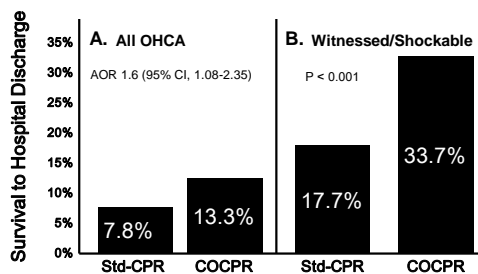


## "Tucson" version (2003) Cardiocerebral Resuscitation (Intubation delayed; Bag Valve Mask ventilation)



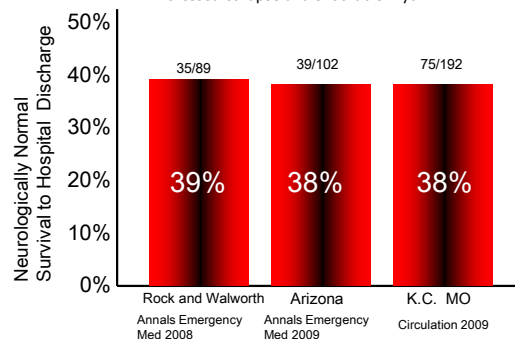
• If adequate bystander chest compressions are provided, EMS providers perform immediate rhythm analysis and shock if indicated

Survival after Bystander CPR for OHCA in Arizona (2005 to 2010)  
Compression Only CPR Advocated and Taught



Bobrow, et al. JAMA 2010;304:1447-1454

## Neurologically Intact Survival from CCR Witnessed collapse and shockable rhythm



## Survival when adding real-time feedback device and simulator training

EMERGENCY MEDICAL SERVICES/ORIGINAL RESEARCH

The Influence of Scenario-Based Training and Real-Time Audiovisual Feedback on Out-of-Hospital Cardiopulmonary Resuscitation Quality and Survival From Out-of-Hospital Cardiac Arrest

Bentley J. Bobrow, MD; Tyler F. Vadeboncoeur, MD; Uwe Stolz, PhD, MPH; Annemarie E. Silver, PhD; John M. Tobin, CEP; Scott A. Crawford, EMT-B; Terence H. Mason, RN; Jerome Schaefer, CEP; Gary A. Smith, MD; Daniel W. Spaite, MD

Cardiac Arrests (484), Mesa, AZ

Phase 1 CPR (n=232)  
without real-time feedback

29.7%

Witnessed/  
Shockable

Phase 2 CPR (n=252)  
With real-time feedback  
and pit crew training

45.7%

(OR 2.7)

**Ann Emerg Med 2013** Good Neurologic Survival to DC

**pennsylvania**  
DEPARTMENT OF HEALTH  
BUREAU OF EMERGENCY MEDICAL SERVICES

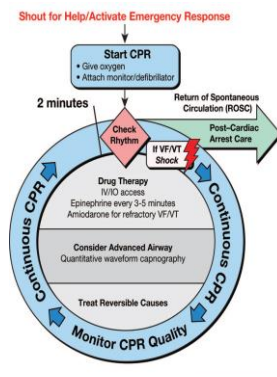
**HeartRescue**  
PROJECT  
PENNSYLVANIA

## Bringing Science to the Pit Crew: High-Functioning EMS CPR Teams

“The Pit Crew Approach”

## AHA 2010 Guidelines

- C-A-B
- Uninterrupted chest compressions
- Waveform capnography
- Deemphasized:
  - Intubation
  - Drugs
  - Mechanical CPR

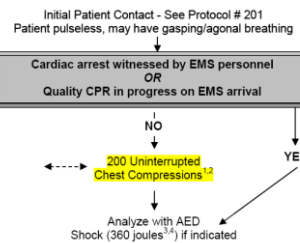


© 2010 American Heart Association

## Statewide Protocols 331A/ 3031A General Cardiac Arrest - Adult

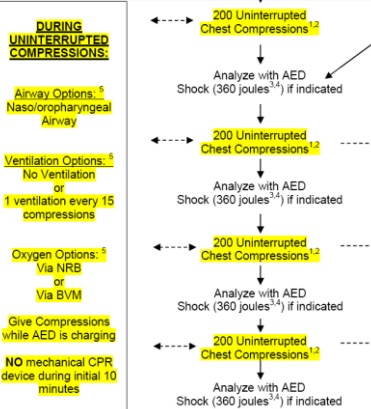
- Don't be fooled by agonal respirations
- Cycles of 200 uninterrupted compressions
- Early defib if good bystander CPR or EMS witnessed arrest

### GENERAL CARDIAC ARREST – ADULT STATEWIDE BLS PROTOCOL

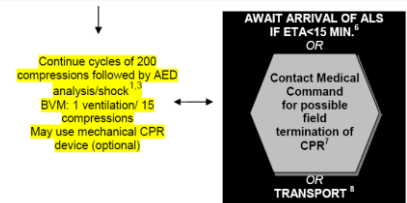


## 331A

- 4 cycles of 200 compressions/defib
- Compressions cause passive ventilation
- Medical director sets airway/ventilation options



## 331A

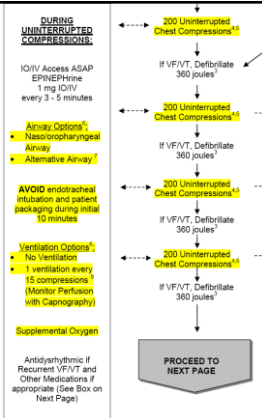


- After 4 cycles of 200 uninterrupted compressions, add ventilations at 15:1
- Indications for possible BLS field termination of CPR
  - Arrest not witnessed by EMS, AND
  - No ROSC/pulse prior to transport, AND
  - No AED shock delivered prior to transport

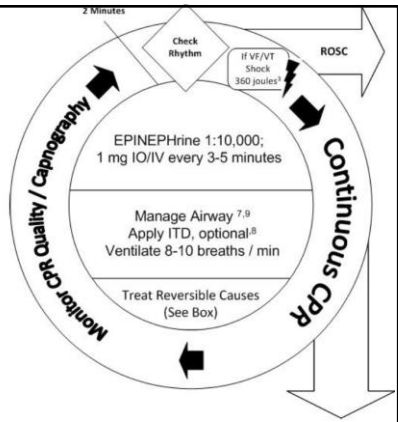


## 3031A

- EPINEPHrine every 3-5 minutes
- Antidysrhythmic if 2<sup>nd</sup> shock needed
- Medical director sets airway/ventilation options for agency
- Monitor capnography
- Avoid intubation during initial cycles of compressions



## 3031A



## 3031A

- Treat reversible causes
  - Pneumothorax
  - Hypovolemia
- Appropriate medication
  - Antidysrhythmic
  - Mg for torsades (rare)
  - Calcium/bicarbonate in dialysis
- Avoid inappropriate care
  - Naloxone
  - Glucose testing

**OTHER MEDICATIONS/ TREATMENTS**

For recurrent VF/VT:

Amiodrone 300 mg IV/IO<sup>11</sup> OR Lidocaine 1.5 mg/kg IV/IO<sup>12</sup>  
(if available)

OR  
If torsades de pointes:  
Administer Magnesium sulfate 2 g IV/IO (if available)

Sodium bicarbonate not indicated unless hyperkalemia or tricyclic antidepressant overdose

If hyperkalemia suspected in dialysis patient administer:  
Calcium Cl (10%) 10 mL IV/IO (if available)

Sodium bicarbonate 1 mEq/kg IV/IO

If hypovolemia suspected:  
Give NSS 2 liters wide open.

Naloxone and Glucose are not indicated in cardiac arrest

If intubated, assess for tension pneumothorax or misplaced ETT.

If tension pneumothorax suspected, perform needle decompression

## High-Functioning CPR Agency The Pit Crew Team



## Equipment organized to be efficient



## Team member roles pre-assigned



## Frequent practice/ simulation



## Team Leader Attributes NREMT (Draft)

1. Creates, implements and revises an action plan
2. Communicates accurately and concisely while listening and encouraging feedback
3. Receives, processes, verifies, and prioritizes information
4. Reconciles incongruent information
5. Demonstrates confidence, compassion, maturity, (respect for team members), and command presence
6. Takes charge
7. Maintains accountability for team's actions/outcomes
8. Assesses situation and resources and modifies accordingly

## Team Member Attributes NREMT (Draft)

1. Demonstrates followership – is receptive to leadership
2. Maintains situational awareness
3. Utilizes appreciative inquiry
4. Avoids freelance activity
5. Uses closed-loop communication
6. Reports progress on tasks
7. Performs tasks accurately and in a timely manner
8. Advocates for safety and is safety conscious at all times
9. Leaves ego/rank at the door

## Pit Crew Approach Compressions are Priority

- Continuous chest compressions with minimal interruption are key
- USE any available feedback device/ metronome
- Alternate compressions between providers across patient's chest (e.g. 100 each)
- Chest compressions should continue when charging an AED or manual defibrillator
- Chest compressions should resume immediately after any shock

Goal = keep interruptions for rhythm check/defibrillation < 10 seconds

Goal = NO interruption for airway device insertion

## Pit Crew Approach "The Triangle of Life"

**3LS)**  
Intraoral airway  
mask or BVM  
(ice  
ion technique)

with  
sessions

**POSITION 1 (BLS)**  
-Assess patient and start CPR  
-Alternate 100 compressions with  
Position 2  
- Analyze/ Shock immediately after  
every 200 compressions  
-Ventilate in off cycle every 15 compressions

pennsylvania  
Department of Health

### 2-Person Pit Crew Example (BLS)

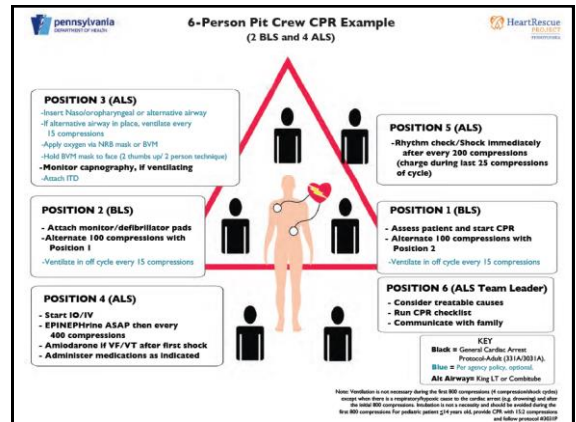
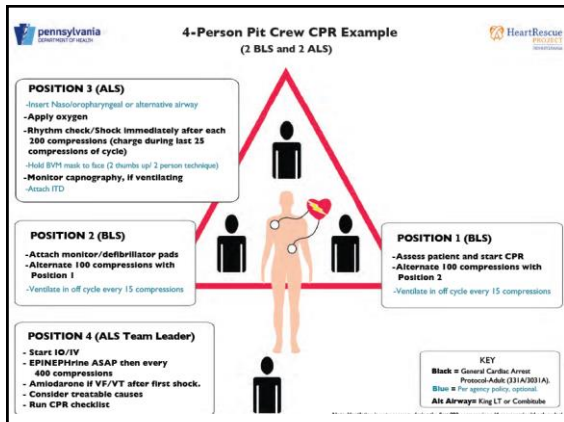
HeartRescue  
Innovations

**POSITION 2 (BLS)**  
-Attach AED  
-Alternate 100 compressions with  
Position 1  
-Ventilate in off cycle every 15 compressions

**POSITION 1 (BLS - Team Leader)**  
-Assess patient and start CPR  
-Alternate 100 compressions with  
Position 2  
- Analyze/ Shock immediately after  
every 200 compressions  
-Insert Nasopharyngeal airway  
- Apply oxygen via NRB mask or BVM  
- Ventilate in off cycle every 15 compressions

**KEY**  
Black = General Center Arrows  
Pit Crew Arrows (BLS)  
Blue = For agency policy, optional





## Pit Crew Approach Airway Options During CPR

- Airway insertion must not interrupt compressions !
- Intubation deemphasized and should be delayed until after 800 compressions
- Options with 3031A (set by medical director):
  - Naso/oropharyngeal Airway + NRB oxygen
  - King LT/ Combitube + oxygen



## Pit Crew Approach Ventilation Options During CPR

- Avoid Hyperventilation!
- Options with 3031A (set by medical director):
  - No ventilation during initial 800 compressions (with open airway, there is passive ventilation with compressions)
  - 1 ventilation/ 15 compressions
- Monitor ventilation by capnography
- ITD optional



## Pit Crew Approach Breathing / Ventilation Summary

- Ventilation not needed during initial 4 cycles of CPR for PRIMARY CARDIAC ARREST
- Ventilation still has role in:
  - Pediatrics, <15 y/o (15:2)
  - Secondary Cardiac Arrest (15:1)
    - Drowning
    - Hypoxic Cardiac Arrest
    - Suspected Respiratory Cause
    - Overdose, etc.

## Pit Crew Approach Two-Person Two-Thumbs-Up BVM

## Pit Crew Approach Medications During CPR

- Routes
  - ? IO first line access
  - ETT ineffective
  - No role for checking labs
- Role of medications
  - Epinephrine (IIb)
    - Ideally within first minute
  - Antidysrhythmic (IIb)
    - For refractory VF/VT



## Pit Crew Approach Mechanical CPR Devices

- Mechanical CPR devices do not lead to more survivors than manual CPR
- Minimizing interruption in chest compressions during first 10 minutes of cardiac arrest is critical, so **mechanical CPR device by BLS providers must be delayed** until after the first 4 cycles of uninterrupted compressions/defibrillation attempts

## Pit Crew Approach How can we monitor our success?

- Real-time feedback
  - Feedback from monitor/AED
  - Continuous waveform capnography
- Post-code
  - Debriefing
  - QI Review
  - Benchmarking (Cardiac Arrest Registry for Enhanced Survival – CARES)

## Pit Crew Approach High-functioning Team

- Teamwork
  - Leadership
  - Situational Awareness (Roles)
  - Communication
  - Mutual Support
- Role of Checklist
- Designed for Efficiency/ Uniformity
- Evidence-based
- “Perfect practice makes perfect”
  - Initial training/ Simulation
  - Regular practice/ Simulation

## 3080 – Post-resuscitation Care Checklist

Before moving patient:

- ☐ Augment marginal BP with IV fluid bolus and pressor drip
- ☐ Obtain 12-lead ECG if possible
- ☐ Titrate O2 to SpO2 between 95 – 99%
- ☐ Monitor continuous ETCO2 and ventilation rate if advanced airway
- ☐ Mask travels with bag-valve no matter what airway is in place
- ☐ Package on backboard/firm surface
- ☐ Is transport to center capable of PCI / hypothermia possible?

## Conclusion



- Improved Dispatch/Bystander CPR
- High-quality uninterrupted compressions
- NASCAR Pit Crew Approach to Cardiac Arrest
- Transport to hypothermia/PPCI Center
- QI – Measure Our Outcomes
- Celebrate Our Success !!



Thank You!

Dr. Gordon Ewy (Univ. of Arizona)

Dr. Benjamin Abella (Univ. of Pennsylvania)  
for providing several slides to this presentation